Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava
číslo 1, rok 2009, ročník LII, řada hutnická
článek č. 1424

MECHANICAL PROPERTIES OF ARAMID–EPOXY LAMINATES

R.VALÁŠEK[1*], I. RUŽIAK[2], J. MATIAŠOVÁ[1]

[1*] *Faculty of Industrial Technologies, Department of Physical Engineering of Materials, Alexander Dubček University of Trenčín; Púchov, Slovak Republic, valasek@fpt.tnuni.sk*
[2] *Faculty of Industrial Technologies, Institute of Materials and Technological Research, Alexander Dubček University of Trenčín; Púchov, Slovak Republic, ruziak@fpt.tnuni.sk*

ABSTRACT: Mechanical properties of materials play an important role in material safety conditions. Laminates are materials which are more and more used in different applications year by year. Their extraordinary properties include high mechanical properties, resistivity against fire and other. Young's modulus of elasticity E, yield stress R_p, tensile strength R_m and ductility A also belong to these mechanical properties. Very important characteristic of materials is stress-strain curve which describes material behavior in process of mechanical loading. In the work, we are dealing with stress-strain curve determination and we compute tensile strength and ductility. Mechanical properties of different aramid-epoxy laminates are compared as well as stress-strain curves.

KEY WORDS: stress-strain curve, tensile strength, laminate, composite

1. INTRODUCTION

In the article [1], authors have dealt with determination of resonant frequencies and mode shapes of laminates by ESPI method. In the article [2], authors deal with the determination of mechanical properties of laminates including titan alloys. In the article [3], authors describe mechanical properties and fracture behavior of Al_2O_3 laminates.

2. THEORETICAL BACKGROUND

In tensile test done according to STN EN 10002-1, tested samples are loaded with constant speed, which is described by material norm. Four mechanical properties are evaluated:
- Tensile strength R_m
- Yield stress R_p
- Ductility A
- Contraction Z

Special routine enables us to determine Young's modulus E, limit of proportionality and limit of elasticity.

Stress σ is defined by equation
$$\sigma = \frac{F}{S} \tag{1}$$
where: F - force [N]
S - area perpendicular to force [mm^2]

Relative extension ε is defined by equation
$$\varepsilon = \frac{dl}{l_0} \tag{2}$$
where: dl - sample extension measured by extensometer on working part of sample [mm]

l_0 - initial length [mm]
Note: When extensometer PS25C is to tensile machine Hounsfield H20K-W we use $l_0 = 25\ mm$.

Tensile strength R_m is defined for every material as ratio of maximal force with initial area of sample. It can be described by equation

$$R_m = \frac{F_m}{S} \tag{3}$$

where: F_m - maximal value of force in test [N]
S - initial area of sample [mm^2]

Ductility A is defined as permanent extension in sample break dividend by initial length, and it is expressed in percentage. Therefore, it can be described by equation

$$A[\%] = 100.\frac{dl_{\max}}{l_0} \tag{4}$$

where: dl_{max} - extension at sample break [mm]
l_0 - initial length of sample working part [mm]

3. EXPERIMENT

3.1 Measuring Procedure

1. To test machine, module for data acquisition is connected.
2. Data acquisition module is connected to PC via USB port.
3. In tensile test machine menu, the transfer to PC through serial port is set.
4. Test machine is turned on and sample is fixed in jaws of machine.
5. Feed Speed is set.
6. Measurement is launched up to sample break.
7. Accept is pressed in software of data acquisition and after 4 seconds PRINT on tensile test machine is pressed.
8. Exported data in ASCII format – first column force in N and second extension in mm, are saved to the disk.

4. RESULTS

Three samples of aramid-epoxy laminates were used. Sample 3B had directions of fiber placing 4x0°/4x90° and was loaded 90° angle-wise. Sample 3C had directions of fiber placing 4x0°/4x90° alternately and was loaded 45° angle-wise. Sample 3D had directions of fiber placing 4x0°/4x90° and was loaded 45° angle-wise. Table 1 shows geometrical parameters of samples.

Tab. 1: Geometrical parameters of samples

	thickness (mm)	**width (mm)**	**length (mm)**	**area (mm^2)**
3B	1.799	25.164	170	44.725
3C	1.850	24.533	170	45.386
3D	1.850	25.100	170	46.520

Fig. 1 displays stress-strain curve for all samples, curve for 3B sample is black line, for 3C is black dashed line and for 3D black dot and dash line. Table 2 presents mechanical properties of laminates.

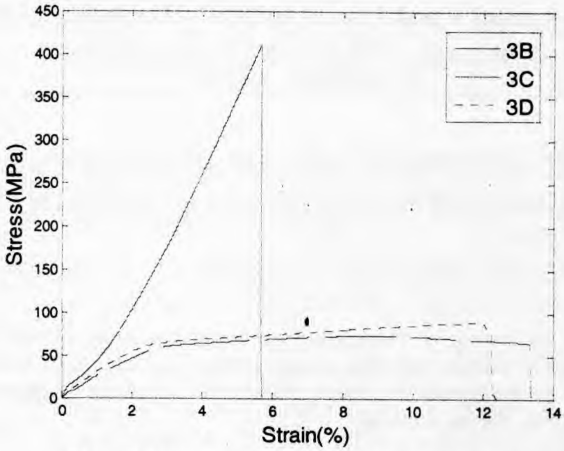

Fig. 1: Stress-strain curve for all 3 samples

Tab. 2: Mechanical properties of samples

	R_m [MPa]	A [%]
3B	410.06	5.74
3C	73.25	13.41
3D	88.71	12.47

5. CONCLUSIONS

From presented stress-strain curves it is clear, that sample 3C and 3D have the same behavior when subjected to tensile stress. Mechanical properties values also confirm this fact.

Sample 3B has considerably higher tensile strength and lower ductility. Reason lies in fact, that sample was loaded in the same direction as fiber direction. It is known that laminates have best properties in fiber direction.

Tensile strength of sample 3B is close to 400 MPa which is excellent strength. Tensile strength of steel is in interval between 373 - 980 MPa, that of aluminum is close to 70 MPa. In the basis of presented results we can come to conclusion, that laminates can be used when high strength is required. We can also conclude that laminates in fiber direction have best properties and properties in other direction are expressively decreased. Obtained results are in good agreement with table values.

Acknowledgement: This work has been supported by project AV 4/2014/08.

6. REFERENCES

[1] RUSNÁKOVÁ, S.: In: *The 6th Youth Symposium on Experimental Solid Mechanics*, 2007, p. 279-282, Vrnjacka Banja, Serbia Montenegro.
[2] PARTRIDGE, P.G. et al.: Comparative analysis of mechanical properties of laminates composed of layers of titanium alloy and titanium alloy metal matrix composites, *Material science and technology*, 1996, vol. 12, no 11, pp. 923-927.
[3] SHE, J. et al.: Mechanical properties and fracture behavior of Al_2O_3 laminates with different architectures, *Materials Letters*, vol. 46, issue 2-3, p. 65-69, 2000.